PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. _____

Project No. E-21-629 GTRI/~~GTL~~ DATE 3/22/83

Project Director: J. F. Dorsey School/~~Lab~~ Elect. Engr.

Sponsor: Georgia Power Company

Type Agreement: Research Project Agreement No. E-21-629, dtd. 3/3/83

Award Period: From 2/24/83 To ~~11/30/84~~ 6-30-85 (Performance) _____ (Reports)

Sponsor Amount: Total Estimated: $ 64,299 Funded: $ 64,299

Cost Sharing Amount: $ 16,928 Cost Sharing No: E-21-312

Title: Design and Development of Procedures for Determining Power System Reduced Order Dynamic Equivalent Modules

ADMINISTRATIVE DATA

OCA Contact William F. Brown Ext. 4810

1) Sponsor Technical Contact:

2) Sponsor Admin/Contractual Matters:

Mr. Clayton H. Griffin
Georgia Power Company
P.O. Box 4545
Atlanta, GA 30302

(404) 526-2450

ALL BILLING MARK:
ATTN: C.H. GRIFFIN (18-270)

Defense Priority Rating: None

Military Security Classification: None

(or) Company/Industrial Proprietary: _____

RESTRICTIONS

See Attached ---- Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with _____

COMMENTS:

To comply with Georgia Power requirement (their letter 3/10/83), Electrical Engineering will furnish Grants and Contracts Accounting with a letter progress report each month to accompany the invoices.

Georgia Power will make advance payment of $1,600 to be applied against the final invoice. Any remaining balance will be refunded at the end of the project.

COPIES TO:

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GTRI
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Project File
Other Dorsey
Other _____

FORM OCA 4:781 (Rev 982)

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

2-SR966

Date 4/4/86

Project No. E-21-629 School/Lab EE

Includes Subproject No.(s) N/A

Project Director(s) J.F. Dorsey GTRC / ~~GIT~~

Sponsor Georgia Power Company

Title Design and Development of Procedures for Determining Power System Reduced Order Dynamic Equivalent Modules.

Effective Completion Date: 6/30/85 (Performance) (Reports)

Grant/Contract Closeout Actions Remaining:

Last Deliverable was a Software package which has been delivered per J.F. Dorsey.

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

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Accounting
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Other Heyser, Embrey, Jones

FORM OCA 69.285

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

April 14, 1983

Mr. Clayton Griffin
Manager,System Protection and Control
P.O. Box 4545
Atlanta,Georgia 30302

Dear Clayton:

This is the first project report on the dynamics equivalents software package, hereafter referred to simply as the project. I have secured a graduate student to work on this project. I am very pleased that I have been able to convince George Troullinos to work for me, because he is one of the very best undergraduate students that I have had here at Georgia Tech. George will not officially become a graduate student until the fall, but Roger Webb has picked him up as an undergraduate assistant in the mean time.

I have spent the last month bringing George up to speed on the business of dynamic equivalents, and describing in a macroscopic way the individual software modules that we have to implement, and the manner in which these modules fit together. In addition, George and I have been researching two papers in the area of balanced realizations. Balanced realizations can perhaps be described qualitatively as follows. Every system has is own natural modes of oscillations some of which are more important than others. The standard trick is to test the individual modes to see if they are observeable or controllable. In the context of the equivalents program, modes of the external system that are either unobserveable or uncontrolliable are then discarded. The balanced realization perspective is that there is a preferred coordinate system in which to investigate the controllability and observeability of system modes. That is, one essentially transforms the original system into a "balanced" system before making the tests for observeability and controllability. George and I have been looking very hard at these papers to determine how they can impact the assembly of the global model we intend to build of the Southern Electric System.

The next step in the project is to begin implementing on the Prime System, the software modules necessary to do the global analysis of the Southern Electric Company. That means that we need to have a meeting as soon as possible to discuss the following issues:

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TELEPHONE: (404) 894-

1. Remote access to the Prime computer.

2. Education of Georgia Tech personnel on the Prime operating system.

3. Making the proposed software "user friendly."

The first two issues will necessitate the presence at this meeting of Southern Company Services, or Georgia Power, personnel familiar with the Prime computer. The third issue will involve planning personnel who have to ultimately use this software. At this meeting I plan to outline, in some detail, the overall structure of the software to be installed, and how I envision that it will "interact" with the user. Thus it is necessary that those present at the meeting represent both the systems aspect of the problem,i.e., how the computer works, and the user aspect. I would appreciate any counsel you can provide in setting up this meeting.

Sincerely,

John F. Dorsey

cc: David Welch
Audrey Bryant
Pat Heitmuller (OCA), 2
File (E21-629)

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894- 2945

May 16, 1983

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Ref: Project Entitled, "Design and Development of Procedures for Determining Power System Reduced Order Dynamic Equivalent Modules"

Dear Clayton:

This is the second project report on the dynamics equivalents software package, hereafter referred to simply as the project. An initial meeting on the project was held May 5, 1983, at Georgia Power to discuss the logistics of the project, and to refine the expectations of Georgia Power and Southern Company Services as to the capabilities of the software to be installed.

It was decided that the software would be installed first on the Amdahl system at the main computing facility at the Perimeter Center. This is fine with me, but you should be aware that it introduces an intermediate step. There are bound to be differences between the operating systems of the Amdahl and the Prime. Whether these differences will be significant or not is not clear to me at this moment, because I have no familiarity with either system. A second issue is the matter of the language in which the software is to be written. The standard for Southern Company is Fortran 77 with which I am unfamiliar, but it certainly seems necessary to write this software in the language standard to Southern Company. I have asked for copies of the Fortran 77 manuals for both the Amdahl and the Prime. It will also be necessary for me to obtain authorization to use the computing facility at Perimeter Center. That authorization is expected to take a couple of weeks.

There was some discussion about the data interface between the new software and the existing transient stability software. It is the feeling of Southern Company that the output of the new software should be in the form of "raw load flow data." This requires the new software to include a network reduction algorithm. This is not something I had planned on doing, but I have consented to do so. I have asked for necessary data formats.

There was some discussion of how the new software could be of direct use to Georgia Power. Unfortunately, I have the impression that it will not be. This is of some concern to me, and I hope to be able to structure the software so that qualitative stability information will be relatively easy to obtain.

The next action that I can take is to begin installing the software for the

production of global equivalents on the Amdahl. To do so I need authorization to use that system. In the interim, George Troullinos and I are continuing to investigate the area of balanced model, in hopes of improving the global equivalents software.

Sincerely,

J. F. Dorsey

JD:ms

cc: M. Segraves
R. Webb
Grants & Contracts Accounting(E21-629)
OCA (2)

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

June 22, 1983

Mr. Clayton Griffin
Manager,System Protection and Control
P.O. Box 4545
Atlanta,Georgia 30302

Dear Clayton:

This is the third project report on the dynamics equivalents software package, hereafter referred to simply as the project. A preliminary study of the use of balanced realizations to predict the break points in the accuracy of the reduced order models has been completed. The results are very encouraging and indicate that it should be possible to provide the user with a concrete numerical criterion for assessing the relative accuracy of models of different levels of reduction. The numerical techniques required to implement this approach are significant. However, some efficient calculation routines developed at the University of Toronto are being investigated and will hopefully make the numerical calculations manageable.

The software necessary to construct the global model has been loaded on the Amdahl system, along with the data for the 86 generator, 600 bus model of the Southern Electric System. The next task is to modify the software so that it will compile and execute on the Amdahl system. Following that verification two tasks will proceed in parallel. The first task is the development of the user interface software that will permit the user to communicate with the basic software modules used to build the global model. The second task is to begin to develop the global model for the complete system. These tasks can proceed in parallel. This means that by mid-July I will need the data base for the complete system, with the data in the same format as that of the 86 generator model. I intend to communicate my needs for this data base to the System Planning group at Southern Company Services this week.

Sincerely,

John F. Dorsey

cc: R. P. Webb
OCA (2)
D. Welch

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

July 12, 1983

Mr. Clayton Griffin
Manager,System Protection and Control
P.O. Box 4545
Atlanta,Georgia 30302

Dear Clayton:

This is the fourth project report on the dynamic equivalents software package, hereafter referred to simply as the project. The two major programs necessary to build the global model of the Southern Electric System are now running on the Amdahl Computer System in batch mode. It is now possible to begin the analysis of the complete system. I have had one phone conversation with Hamish Wong, and it appears that the data for this analysis can be generated in a very short period of time, say a day or so. I plan to have a meeting with Hamish this week, since he will be in Atlanta. We should be able to complete the arrangements for the data at that time.

The analysis of the complete(2500 buses, 600 generators) model will be done in the batch mode on the Amdahl. In parallel with that I plan to begin working on the interactive version of the global model that will ultimately be used on the prime. I should have a preliminary version of this software ready in a week or so. At that time I would like to have Transmission Planning try it out and indicate any changes they may want.

In talking with Hamish, one issue resurfaced which probably deserves some comment. It is the desire of Transmission Planning that I develop a network reduction program, that will reduce the network, based on the generator groupings dictated by the coherency analysis. It was not my original understanding that I would have to develop this piece of software. I had envisioned that as something that would be taken care of by the Transmission Planning manpower allocated to this project. Be that as it may, I will certainly develop the necessary network reduction routine. Quite frankly, I would prefer to use the EPRI network reduction routine, unless there is some proprietary reason why that cannot be done.

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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

The train appears to be finally moving. The initial going has been a little slow and frustrating for me, because I am unfamiliar with the IBM operating system and the infamous JCL language. I think I am fairly well up to speed. I still need to learn how to use the interactive mode of the IBM system, but I should reach that goal in a week or so.

Sincerely,

John R. Dorsey

cc: R. Webb
D. Welch
B. Armstead
OCA (2)
File - E21-629

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

August 17, 1983

Mr. Clayton Griffin, Manager
SYSTEM PROTECTION AND CONTROL
P.O. Box 4545
Atlanta, GA. 30302

Dear Clayton:

This is the fifth project report on the dynamic equivalents software package, hereinafter referred to simply as the project. I have encountered some difficulties with the Amdahl system, which I will try to outline briefly. As I understand it there are two computers that I am involved with, which I will refer to as the CMS and MVS systems. All of the control that I exercise, in terms of the programs that I select to run, is done on the CMS system. The programs actually run on the MVS system. These two computer systems are linked together by a shared memory area. When I run a program, it is passed through the shared memory into the MVS system where it executes. The problem is that the data generated by this program is dumped into mass storage on the MVS. To get that data back to the CMS system is a cumbersome problem. The other problem is that once the data comes back to CMS, I have no place to put it. The nature of the difficulty is perhaps clearer if I point out that the software I am trying to build up is a long string generating data used by subsequent programs. For instance, in the case of the global model package a program called Glodata, reads in the basic network structure and creates a file called DDEL. DDEL is used by two subsequent programs, SX and TMATRIX. SX in turn generates a file called CJK which is used by another program called RNKTABL. TMATRIX likewise generates three files which are used by subsequent programs. The point of all this is that what is required is the ability to easily access fairly large blocks of mass storage so that a string of programs can be executed at one time. As far as I can tell this is not possible on the CMS system. At least I have not been able to learn how to do it if indeed it is possible. Even if it were possible, it is apparent that the amount of mass storage I require would probably not be available.

As a consequence, I began some investigations on the CDC system here at Georgia Tech. I am fairly certain that with some careful segmenting of programs, I can analyze the 2500 bus model on the CDC computer. In fact,

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I have already begun converting programs, and hope to transfer the data to the CDC system next week. This is the only solution that I see at the moment. It may be that I can finally resolve the problems with the Amdahl system, but I am not optimistic about that. Everything I have been able to learn about that system indicates to me that it is not going to be feasible to run a sequence of programs each of which has to read and write from mass storage. So at the moment, my only recourse is to try to make these programs run here at Georgia Tech. I will try to indicate in a week or so if I am successful.

Sincerely,

John F. Dorsey

JFD:db

cc: David Welch
Beau Armistead
Roger Webb
File (E21-629)

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894- 2945

September 10, 1983

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton,

This is the sixth project report on the dynamic equivalents software package, hereafter referred to simply as the project. Enclosed is a block diagram layout of the basic software package. The data files form the right hand column, the programs themselves the left hand column. I have provided a description of the function of each data file, plus a tentative name for each file.

The programs on the first page, GLODAT, TMATRIX, EMEASR, RTABLE, GROUP AND GRUPRP produce the basic data needed to analyze the performance of a reduced order model. All of these programs except GRUPRP have been written and function correctly on the CDC Cyber 850 at Georgia Tech. This means that there will be absolutely no storage problems when the programs are converted to the Prime. None of the data files are larger than the original base case, and so I do not envision any data storage problems either.

I have already generated some reduced order models of the 1984 base case. The preliminary results are quite encouraging. So far I have aggregated down to 80 generators. At that level of aggregation there are roughly sixty groups, with only a couple of the groups being large, about fifteen to twenty generators, and the rest being small, anywhere from eight to three generators per group. This is very encouraging in terms of producing "off the shelf" local models useful for disturbances confined to a particular group.

To facilitate the global analysis of the system, I have begun work on a program called GRUPRP which prepares the generator grouping data so that it can be easily used by the programs that appear on page two of the layout. The program called GRUMAP will draw a map of the system and plot at the location of each generator a number corresponding to the group to which the generator belongs. This program is written and I have tried it on a small system. I find this approach very useful in condensing the data into a form

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in which I can see what is going on. Even though GRUMAP is written I have yet to interface it to GRUPRP. This latter program is a new arrival on the scene. I am finding that with 254 generators, I have had to do some additional data massaging that was not apparent with the 84 generator system.

Of the programs on the second page of the layout, GRUMAP, STATMOD, PLOTR, EIGEN, EPLOTR, and NETRED, only PLOTR has been written. I do not envision any problem with STATMOD, EIGEN and ELPOTR which do the basic time domain and eigenvalue analysis of the linearized power system model. I have programs of this nature written for small dimension systems, which can be modified to efficiently handle a large dimension system.

The big unknown at this point is NETRED, which is a network reduction program that has as its output a reduced base case compatible with the Prime. This is not a program I had anticipated writing, and since I am no expert on network reduction, I am uncertain how long it will take me to come up to speed, and decide how I wish to attack this problem. I am betting it will occupy a good deal of my time.

The other task is to write the interactive software that interrogates the user, and then constructs the command file that will cause the various modules to be executed in a sequence that yields the answer the user is looking for. I am now at a point where it is natural to start thinking about that software, since most of the executable modules are now constructed.

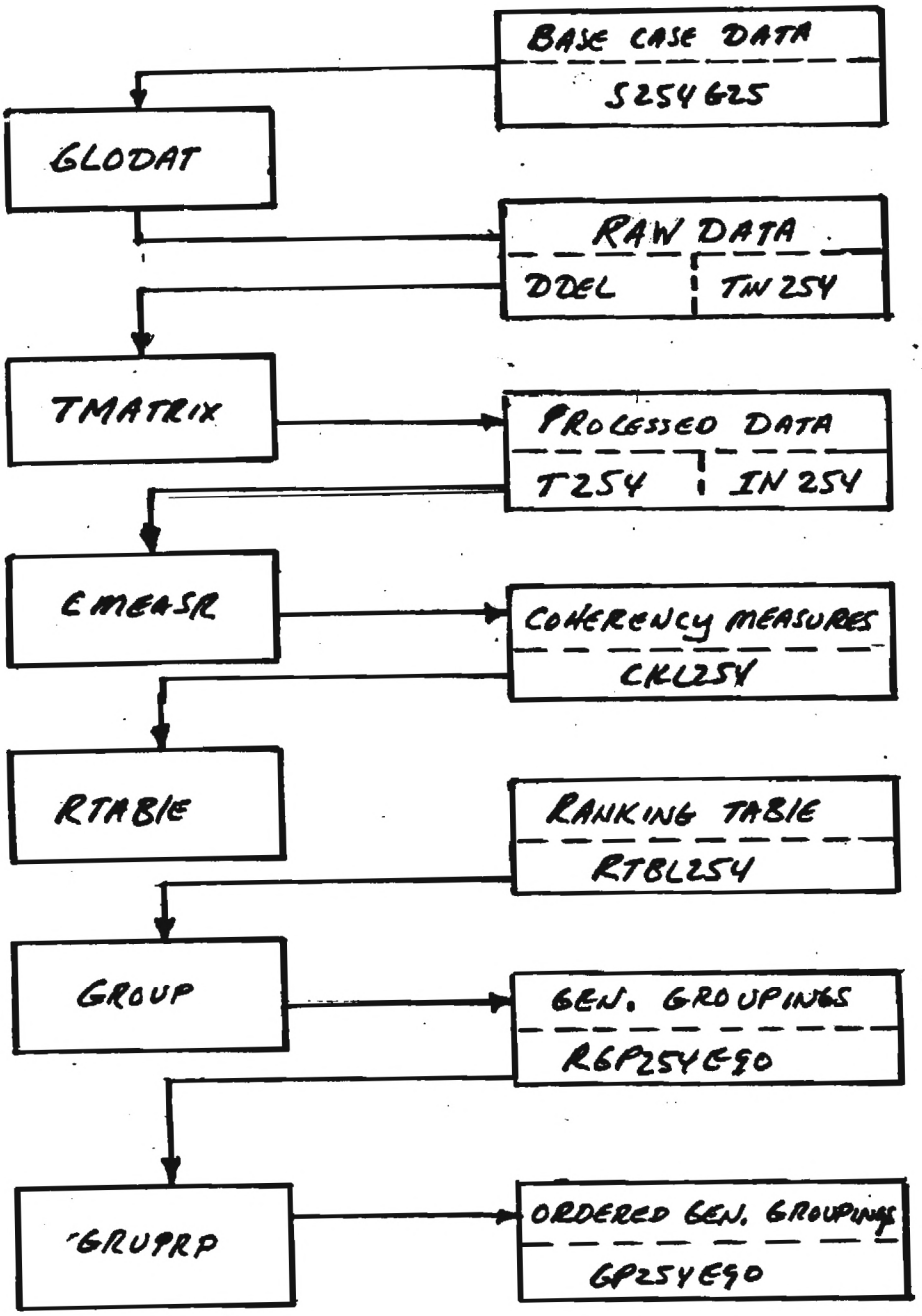
Since roughly six months have elapsed since the start of the project, it is probably appropriate to make an estimate of what percentage of the project has been completed. My estimate is that the overall project is about twenty percent complete. It may appear that I am farther along than that, since all but three or four of the basic software modules are complete. But I cannot at this point accurately estimate how long it will take to complete NETRED. When I get a clearer understanding of what is involved in developing NETRED, I will be able to make a better estimate of the work remaining.

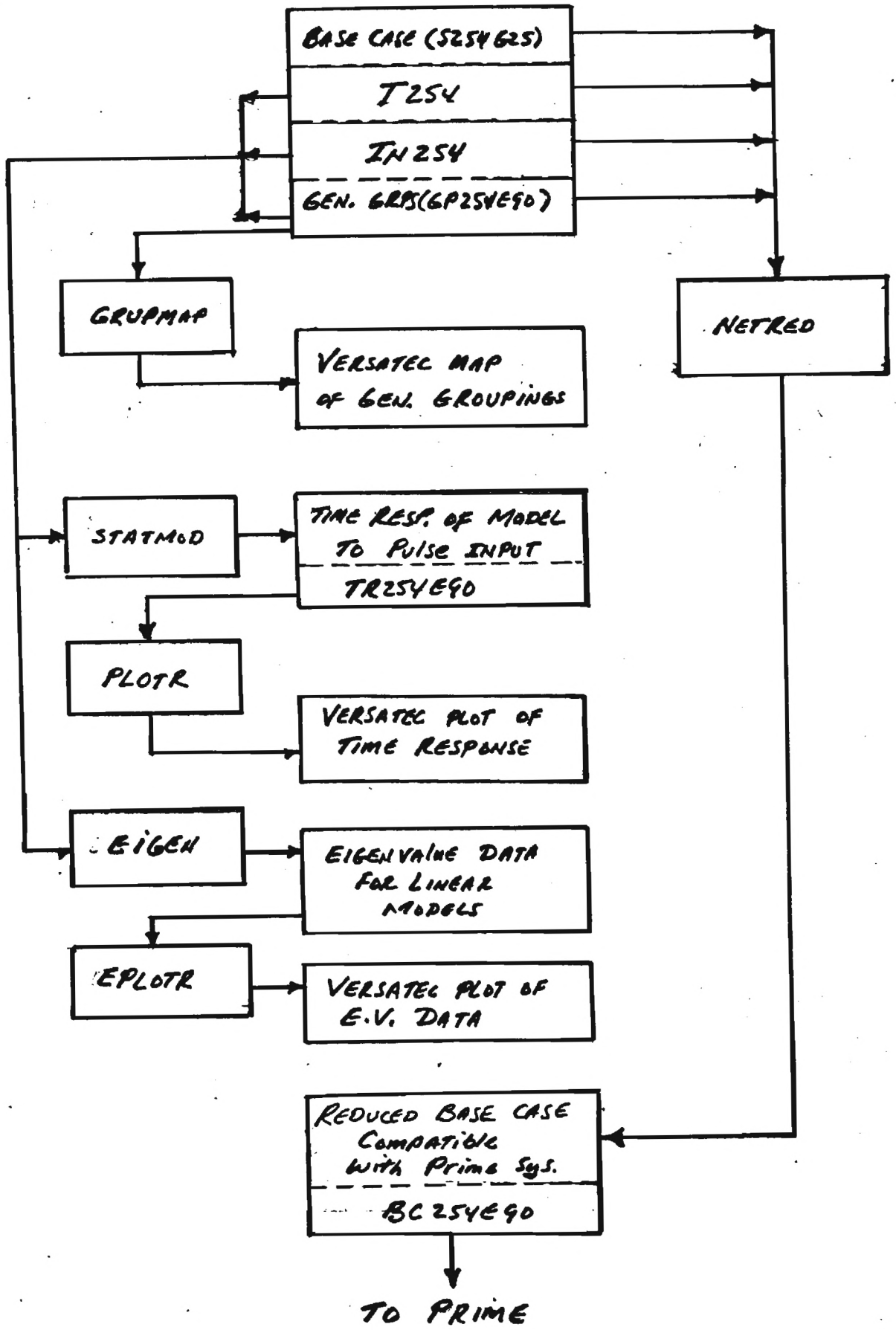
Sincerely,

John F. Dorsey

JFD:db

cc: Beau Armistead
Roger Webb
OCA
File (E21-629)


BASE CASE DATA
S254625
GLODAT
RAW DATA
DDEL
TW254
TMATRIX
PROCESSED DATA
T254
IN254
CMEASR
COHERENCY MEASURES
CRL254
RTABLE
RANKING TABLE
RTBL254
GROUP
GEN. GROUPINGS
RGP254E90
GRUPRP
ORDERED GEN. GROUPINGS
GP254E90


BASE CASE (S254G25)
T254
IN254
GEN. GRPS(GP254EGO)
GRUPMAP
VERSATEC MAP OF GEN. GROUPINGS
NETRED
STATMOD
TIME RESP. OF MODEL TO PULSE INPUT
TR254EGO
PLOTR
VERSATEC PLOT OF TIME RESPONSE
EIGEN
EIGENVALUE DATA FOR LINEAR MODELS
EPLOTR
VERSATEC PLOT OF E.V. DATA
REDUCED BASE CASE Compatible with Prime Sys.
BC254EGO
TO PRIME

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-2945

October 19, 1983

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This is the seventh project report on the dynamic equivalents software package, hereafter referred to simply as the project. I am continuing development on program GRUPRP and have the first of several interactive routines written and I am in the process of debugging that software. George Troullinos is continuing work on a set of programs to automatically determine the correct level of model reduction. I have high hopes for this software. A second graduate student has begun work on the network reduction program. A Georgia Power cooperative student, Randy Cobb, who has some expertise with the CDC computer system, has asked to work on the interactive software for his senior project. There are a number of loose ends at the moment, but I am confident that the package will be more than satisfactory.

Sincerely,

//John F. Dorsey

JFD/db

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894- 2945

November 17, 1983

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

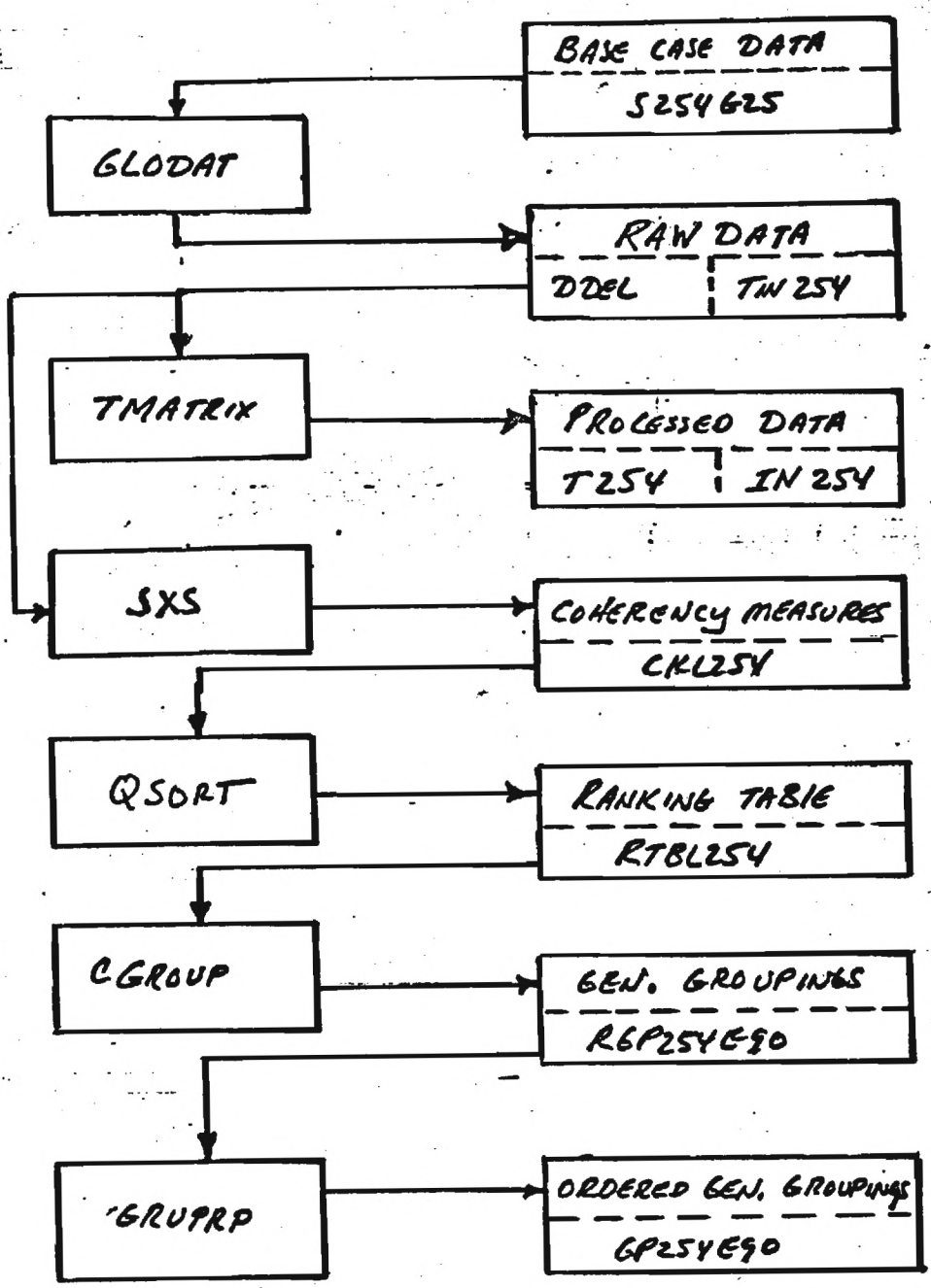
This is the eighth project report on the dynamic equivalents software package, hereafter referred to simply as the project. Enclosed is an updated flow diagram of the software modules. As you can see there are a couple of minor changes and additions. I have altered slightly the method of generating the ranking table of coherency measures. There are several ways by which this table can be generated, and my latest thinking centers on computational efficiency. I have also added the module MTMAT. This program calculates the matrix MT which then can be used by the subsequent programs STATMOD, PLOTR, and EIGEN. During October, GRUPRP was finished and STATMOD and PLOTR rewritten to make them computationally efficient for systems of high dimensionality. In addition, an interactive software routine was completed which links the programs GLODAT, TMATRIX, SXS, QSORT, and GROUP together. This program interogates the user and then assembles a command file which executes the necessary programs in the correct order to satisfy the user's wishes.

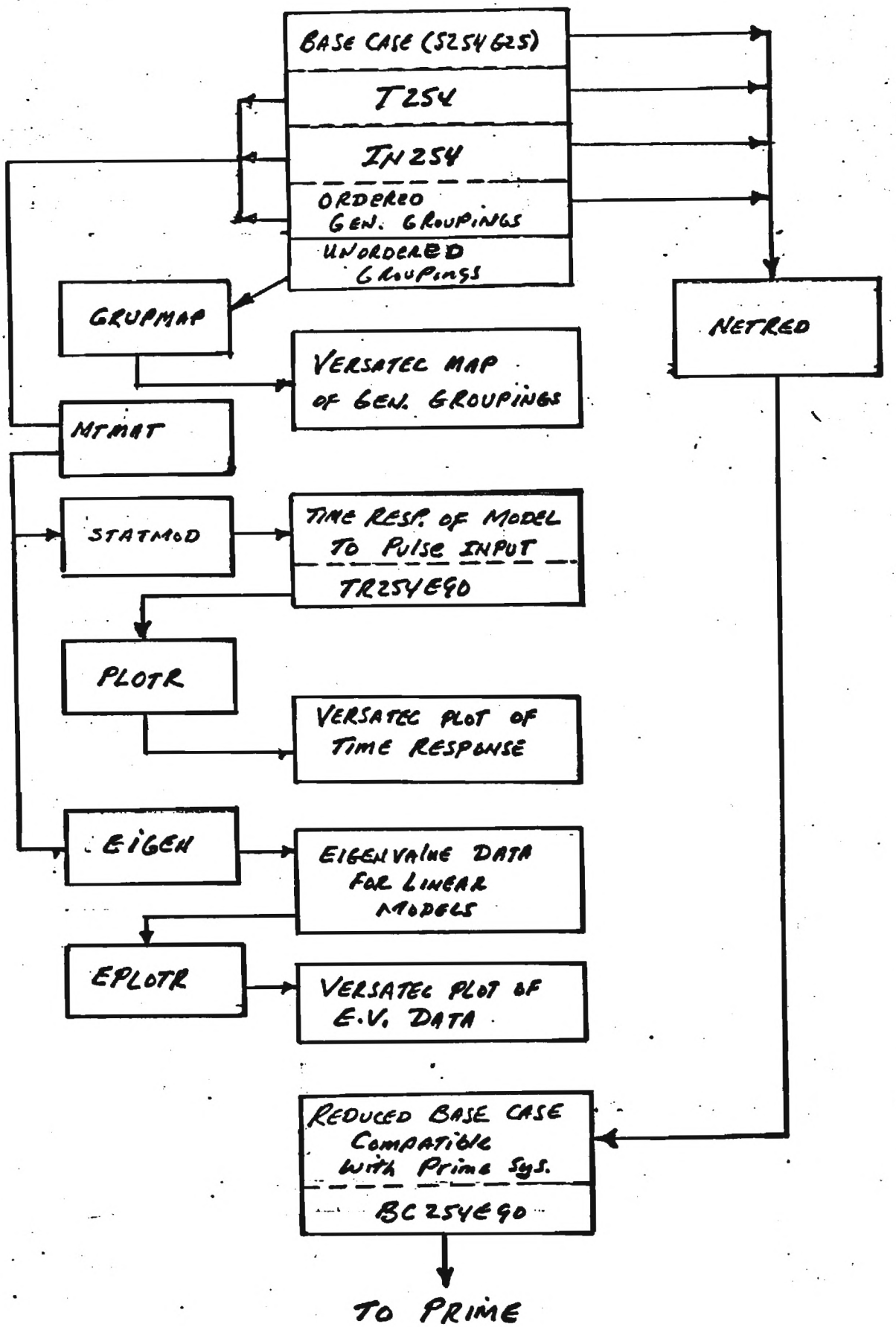
Two modules remain to be written, namely EIGEN and NETRED. EIGEN will be finished by the end of November. In addition by early December, I will have an interactive program that links the user to GRUMAP, MTMAT, STATMOD, and PLOTR. At that point only NETRED will remain, and I plan to begin trying to implement everything except NETRED on the Amdahl, while continuing to work on NETRED here at Georgia Tech.

Sincerely,

John F. Dorsey

JFD/db


BASE CASE DATA
S254G25
GLODAT
RAW DATA
DDEL
TN254
TMATRIX
PROCESSED DATA
T254
IN254
SXS
COHERENCY MEASURES
CKL254
QSORT
RANKING TABLE
RTBL254
CGROUP
GEN. GROUPINGS
RGP254E90
GRUPRP
ORDERED GEN. GROUPINGS
GP254E90


BASE CASE (S254G25)
T254
IN254
ORDERED GEN. GROUPINGS
UNORDERED GROUPINGS
GRUPMAP
VERSATEC MAP OF GEN. GROUPINGS
NETRED
MTMAT
STATMOD
TIME RESP. OF MODEL TO PULSE INPUT
TR254E90
PLOTR
VERSATEC PLOT OF TIME RESPONSE
EIGEN
EIGENVALUE DATA FOR LINEAR MODELS
EPLOTR
VERSATEC PLOT OF E.V. DATA
REDUCED BASE CASE COMPATIBLE WITH PRIME SYS.
BC254E90
TO PRIME

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

December 9, 1983

Mr. Clayton Griffin
Manager,System Protection and Control
P.O. Box 4545
Atlanta,Georgia 30302

Dear Clayton:

This is the ninth project report on the dynamic equivalents software package, hereafter referred to simply as the project. George Troullinos has completed work on a group of programs designed to predict the points in the model reduction process at which major changes in the accuracy of the dynamic equivalents occur. I have very high hopes for this software. The idea was tested in a preliminary way on the 39 Bus New England System last spring and worked very well. George has spent the time since then building production grade software. He and I will begin testing that software next week. If those tests are as successful as I think they will be, then we will have made a giant step towards the automatic production of reduced order equivalents. The details of the interactive software should be cleaned up by the middle of December. At that point I plan to transfer the package to the Amdahl and begin the process of adapting the interactive software to that system. In parallel with that activity, I plan to begin work on the network reduction program, which is the only major software module that remains to be written.

Sincerely,

John F. Dorsey

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

January 20, 1983

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta Georgia 30302

Dear Clayton:

This is the tenth project report on the dynamic equivalents software package, hereafter referred to simply as the project. I have begun installing the software on the Amdahl system. So far I have had very little trouble in converting the Fortran code for the CDC system to Fortan for the Amdahl. My biggest problem is getting a good understanding of the two operating systems, i.e. CMS and MVS, and how they interact. I am also in the process of learning enough about the IBM JCL to reach a point where I can operate independently on the Amdahl system. This is somewhat of a problem at the moment, but hopefully I can reach a point where I understand the system well enough to proceed at my own pace with the implementation.

Concurrent with the installation work, I am trying to establish a valid global model of the system. I believe that this model will be roughly sixty generators. I have included a map of an eighty generator global model, but I believe that this model can be reduced another twenty-five percent.

Work is also proceeding on the network reduction software. That software should be ready to be moved to the perimeter by early February. At that point all the software will be on the Amdahl, and the only remaining task will be to finish the interactive software that interfaces the user to the computational modules.

sincerely,

John F. Dorsey

SUMMER 1984 BASE CASE
80 GENERATOR MODEL
254 GENERATORS IN ORIGINAL MODEL

GROUP NO. 1
321 MORGAN FALLS 115
939 ALLATOONA
20 BOWEN8 500
23 WANSLEY 500
215 MCDNGH1 115
216 MCDNGH2 115
182 HAMMOND6 230
609 GOATROCK3 115
611 NCOLUMBUS3 115
646 OLIVER3 115
607 BARTLFY3 115
604 WATDAM3 115
123 YATES*6 230
621 YATES 115
18 SCHERER8 500
752 LLOYDSHOALS 115
756 ARKWRIGHT 115
147 BRANCH6 230
817 SINCLAIR
155 WALLACE DAM 230

GROUP NO. 2
2855 ALCOA
2854 BULL RUN
3262 FORT LOUDIN
2807 DOUGLASS 161
2866 CLEVELAND
2868 APALACHIA
2867 HIWASSEE
2822 WOLF CREEK
2823 SUMMERSHADE
9004 COOPER
2857 JOHN SEVIER
2856 JOHN SEVIER

GROUP NO. 3
2826 KENTUCKY HYDRO
2808 BARKLEY 161
2844 PARADISE 500
2824 PARADISE 161
2863 GALATST
2812 GUNVLH 115
2862 GUNTVLH
2810 WEST POINT 161
2864 NICAJACK DAM
2865 CHICKAMAUGA HYDRO
3218 WINCHESTER
2853 WATTS BAR
2847 WIDOWS CREEK 2

GROUP NO. 4
5428 MICHOUD
5427 MICHOUD
5431 NINE MILE
5596 GYPSY
5595 GYPSY
5429 WATERFORD
5432 NINE MILE

GROUP NO. 5
3403 C-35
9742 JOPPA N
9743 JOPPA S
9801 COFFEEN

GROUP NO. 6
5119 WGLEN
5311 CAJUN 1
5118 WGLEN
5117 LASTA
5312 CAJUN 2
5011 TECHE

GROUP NO. 7
1155 GORGAS 6
1156 MILLER
1153 GORGAS 1
1142 SMITH LN
1154 GORGAS 3
1355 HOLT GEN

GROUP NO. 8
403 TERRORA 115
421 TUGALO3 115
422 YONAH3 115
404 TALLULAH 115
3801 C.H. GEN 115
3810 CLARK 115
3601 UROUHAR 115

GROUP NO. 9
9025 LEESVILLE
9024 SMITH MTN
9026 GLENLYN
9027 BRADELY
4757 MT. STORM
9053 PEACH BOTTOM

GROUP NO. 10
5115 NELSON
5116 NELSON
5114 SABIN
5113 SABIN
5112 NECHE
5111 LEWIS

GROUP NO. 11
7611 ANCLOTE
7612 BARTOW
8617 MCINTOSH

GROUP NO. 12
7018 CAPE KENNEDY
8615 INDIAN RIVER
7618 TURNER
7020 SANFORD PLANT

GROUP NO. 13
4770 POSSUM
9028 DICKERSON
4776 ANNA
4772 YORKTOWN
4771 CHESTERFIELD
4774 PORTSMOUTH
4777 SURREY
4773 YORKTOWN
4775 SURREY

GROUP NO. 14
5424 WILSON
5426 GGULF
5423 WILSON
5425 REX BROWN
5421 DELTA
5422 ANDRUS

GROUP NO. 15
3918 LEE
4112 HODGES
3902 HARTWELL
4616 ASH SE
3924 JOCASSEE
3901 OCONEE

GROUP NO. 16
8511 A B HOPKINS
8512 PURDAM
1826 LANSING SMITH
1827 LANSING SMITH
1837 SCHOLZ

GROUP NO. 17
3811 JEFFREY 115
3812 CROSS
3610 A M WILSON 230
3814 WINYAH
3815 WINYAH
3615 CANADYS

GROUP NO. 18
681 MTCHL3 115
676 FLINTRV3 115

GROUP NO. 19
3704 SALUDA
3925 NEWBERRY
3612 WATEREE 230
4511 FLO 115

GROUP NO. 20
9744 COUNCIL BLUFF
9719 COOPER
6012 MONTROSE5
5970 IATAN
5975 MINGO
6011 SIBLEY

GROUP NO. 21
3915 ALLEN
3916 ALLEN
3917 CLIFFSIDE
3904 MCGUIRE
3922 MCGUIRE
3919 MARSHALL

GROUP NO. 22
5436 WHITE BLUFF
5434 ARKANSAS/LOUISIANA
5797 WEST MEMPHIS
5439 ISES

GROUP NO. 23
9052 GHENT
9051 GHENT

GROUP NO. 24
2028 TOMBIGBEE6
2029 TOMBIGBEE 3
1700 BARRY
1701 BARRY

GROUP NO. 25
1953 WATSON
1988 DANIEL
2014 MOSSELLE
2024 MORROW

GROUP NO. 26
2811 WILSON 161
2861 WHEELER
3099 TUPELO
2859 PICKWICK
2860 COLBERT

GROUP NO. 27
2409 PLANT RIVERSIDE
2410 PLANT RIVERSIDE
2402 PLANT WENTWORTH
2403 PLANT WENTWORTH
2405 PLANT EFFINGHAM

GROUP NO. 28
5952 SIKESTON
6014 NEW MADRID
5956 NEW MADRID

GROUP NO. 29
7012 PORT EVERGLADES 138
7013 PORT EVERGLADES 230
7015 MARTIN

GROUP NO. 30
7613 CRYSTAL RIVER
7614 CRYSTAL RIVER

GROUP NO. 31
1418 MARTIN DAM
1425 JORDAN DAM
1443 THURLOW DAM
1448 YATES GEN 7
1407 LAY DAM
1428 MITCHELL DAM
1430 BOULDIN DAM
1499 JONES BLUFF

GROUP NO. 32
6013 THOMAS HILL7
5962 THOMAS HILL

GROUP NO. 33
4316 MAYO
4320 ROX SE
4321 ASHBEE 115

GROUP NO. 34
1470 GREENCO
1471 GREENCO
1567 MILLER FERRY

GROUP NO. 35
1176 GADSDEN
1326 WEISS DAM
1306 HENRY DAM
1400 GASTON
1384 L. MARTIN DAM

GROUP NO. 36
8310 SOUTHSIDE
8313 NORTHSIDE
8312 NORTHSIDE

GROUP NO. 37
8614 GANNON
8613 GANNON
8612 BIG BEND

GROUP NO. 38
1754 CRIST
1755 CRIST

GROUP NO. 39
8991 DEPOT
8618 DEERHAVEN

GROUP NO. 40
2045 MCWILLIAMS
2046 MCWILLIAMS

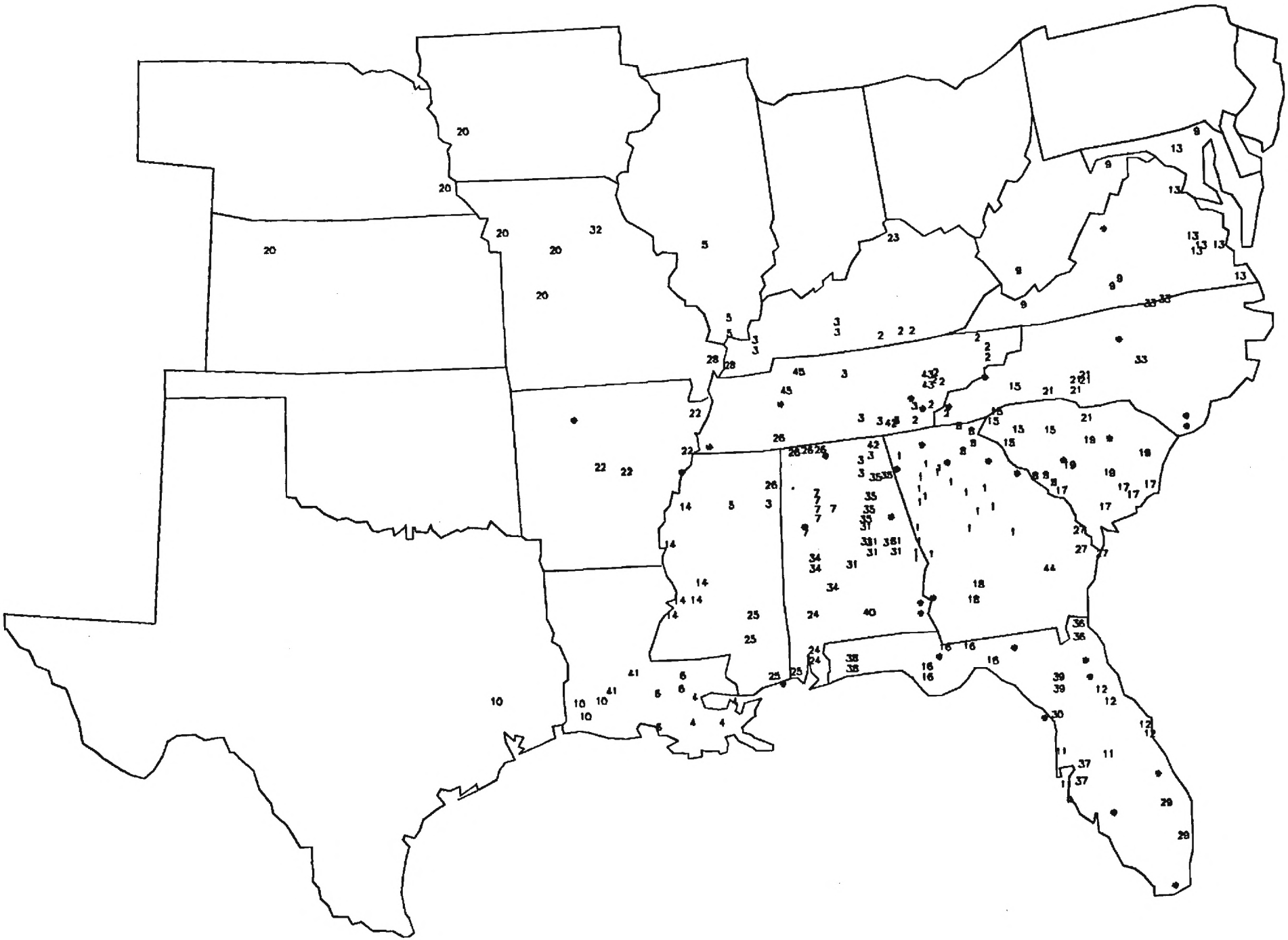
GROUP NO. 41
5013 WDRPLT
5012 COUGHLIN

GROUP NO. 42
2849 RACCOON MTN
2846 WIDOWS CREEK

GROUP NO. 43
2871 KINGSTON 33N
2872 KINGSTON 33S

GROUP NO. 44
14 HATCH8 500
160 HATCH6 230

GROUP NO. 45
2843 CUMBERLAND
2841 JOHNSONVILLE 1



GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894- 2945

February 20, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This is the eleventh project report on the dynamic equivalents software package, hereafter referred to simply as the project. I am in the process of testing the individual programs that comprise the overall package. So far, everything has gone fairly smooth, although I am somewhat handicapped by the fact that I am not very familiar with the IBM operating system. I expect to have all the software operational on the MVS system by the middle of March, with the following two exceptions.

The program NETRED that reformats the data for the reduced order model so that it will run on the Prime system has to be written. The interactive source code that interfaces the user to the computational software has to be adapted to the IBM system. I have a graduate student assigned to the first task. I would estimate that he has completed about forty percent of the work on NETRED.

The second task of rewriting the interactive software is more complicated. Let me try to explain the difficulties. The computer configuration at the perimeter is quite sophisticated. There are several mainframe computers interconnected to a rather extensive and diverse data storage system. In addition, the IBM operating system is by nature more complicated than that of most computer systems. By complicated, I mean that operations that are easy to accomplish on most computer systems, e.g., file management, require a much more extensive knowledge of the system on an IBM computer. The software that remains to be written can only be written efficiently and effectively by someone who is very familiar with the overall operating system. If I undertake this task alone the result is going to be less than optimal. What will happen is that I will have to acquaint myself with the operating system by writing the code. This means that the code will eventually work, but it is not likely to be as elegant and efficient as I would like it to be. Therefore, I would like some assistance. What I require is the assistance of someone who knows thoroughly the overall structure of the computer system at the perimeter and who knows the IBM job control language backwards and forwards. Beginning in late March I need to be able to work jointly with this individual about ten to fifteen hours a week so that I can make the right decisions about how to write the remaining software. I am perfectly willing to write this software, I merely want to insure that it gets written as efficiently and effectively as possible.

I have one other concern. When I first undertook this project, I envisioned spending one-third of my time on it over a period of roughly two years. The project was initially budgeted that way. I am, by nature, not very interested in legal contracts. This is a personal deficiency that has plagued me most of my life. It was brought to my attention recently by the administration here at Georgia Tech that this contract is scheduled to finish the end of this year. This is acceptable to me, but I would prefer to extend the deadline to June of 1985, which is the deadline I, personally, have been working against all along. I can finish this thing by year's end, but Southern Company is going to get a better product if the deadline is extended. It will allow me to do more on the project that I can otherwise.

Sincerely,

John F. Dorsey

JFD/db

GEORGIA INSTITUTE OF TECHNOLOGY
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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-2945

March 22, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This is the twelfth project report on the dynamic equivalents software package, hereinafter referred to simply as the project. All the major modules are now running in batch form on the Amdahl system with the exception of two service routines that require the plotter. I expect to have those routines up and running in a week or so. Charlie Manahan has assigned a programmer to the project, and in approximately ten days, I plan to start work on the Interactive software that will link the user to the computational software in a meaningful way. I cannot tell for sure how long it will take to get the interactive software running in some form, but I would guess sixty days. That means that by late May or early June we should be in a position to let the Systems Planning users have a look at the software to see how they like it. We would then have about a year left on the contract to document and improve the useability of the software. I hope that is enough.

With regards to our conversation concerning the termination date of the project, Marsha Seagraves has worked up an adjusted billing schedule, detailing what money has been spent, and how the remaining funds will be reallocated. Those figures are attached.

Sincerely,

John F. Dorsey

attachment

JFD/db

GEORGIA INSTITUTE OF TECHNOLOGY
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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-2945

April 16, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, GA 30302

Dear Clayton:

This is the thirteenth project report on the dynamic equivalents software package, hereafter referred to simply as the project. The two service routines that use the plotter are now functional. However, the Xynetics plotter is significantly different from the calcomp plotter for which these programs were initially designed. As a consequence, I plan to make some additional changes to these routines to make them easier to use both for the user and for the personnel who run the plotter. That task should be complete by the end of April.

Kirby Holtam has begun work on the interactive software. A preliminary module which allows the user to create the basic data base is nearly finished. Kirby and I have been in communication with Jimmy Myers of Transmission Planning concerning this interactive software. As a consequence of those conversations, I plan to make some minor changes to the basic computational modules which should make the package easier to use. These modifications should take a week to ten days. Following some preliminary testing of my own, I plan to turn the initial software over to Transmission Planning for their testing by the middle of May.

Once the interactive software is completed, and the testing has begun, I plan to turn my attention to the final task of writing the software that computes the network dictated by the reduced order model and puts the data for that network in a form compatible with the PTI software.

Sincerely,

John F. Dorsey

JFD/db

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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

May 29, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, GA. 30302

Dear Clayton:

This is the thirteenth project report on the dynamic equivalents software package, hereinafter referred to simply as the project. The modificaitons to the plotting program are finally complete. This task took somewhat longer than I anticipated, but it needed to be done, because it makes this option much easier to use. I plan to have Kirby Holtam begin work on the interactive software for the plotting routines. Kirby works very quickly, and I expect it will take him only a week or so.

I have added an option to the model building software. This option allows the user to build equivalents of the type used in the original EPRI software, i.e. models designed for specific fault type disturbances at specific points in the system. The software to do this is now written and I am in the process of debugging it. I anticipate it will take two weeks to finish the debugging. In parallel with that task, I have begun working up the preliminary documentation on the project, so that when the final debugging is complete, I can turn the preliminary package over to the user for testing. This will probably be a piecemeal operation. That is when I have the documentation for a particular option complete I will turn it over to the user for testing while I continue to work on the rest of the documentation. Hopefully, the documentation for the first two options will be available to the user by the end of June.

Sincerely,

John F. Dorsey

JFD/db

GEORGIA INSTITUTE OF TECHNOLOGY
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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

June 28, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, GA 30302

Dear Clayton:

This is the fifteenth project report on the dynamic equivalents software package, hereafter referred to simply as the project. I have been working with Kirby Holtam on the interactive software that links the user to the computational routines. This software is all written, but in the course of testing the software, both Kirby and I concluded that the data entry was too difficult. Therefore, I have spent the last few weeks reworking the data structure of the computational routines. Basically, I compressed several datasets into larger, single datasets, so that the user would have a much simpler file management system. This work is complete, and Kirby and I are now in the process of reworking the interactive software. I expect this will take a week or two to complete. I have begun work on the documentation, and plan to ship some of the preliminary documentation to Birmingham next week.

I have also begun work on the data reduction task. At present, I am trying to see if the original program DYNAGG will be useful in determining the dynamic characteristics of the composite generators that replace the coherent groups. The present EPRI software no longer uses this program, but instead substitutes a simple second order model for each composite generator. There are many people in the power industry who claim that this is all that is required. However, I thought I would try to implement this program on the MVS system anyway. My impression from working with the original version of DYNAGG is that it is not a particularly well written piece of software, and this might have influenced EPRI to stop using it.

George Troullinos has been working on some software that provides an estimate of how far the original system can be aggregated. So far we have tested this software on three sets of data, and are now testing it on the large 254 generator system. The results are very good, and I plan to add this software to the overall package.

In the course of developing this software, I have decided that a few more options, beyond what I had originally intended would be beneficial to the user. The work that George Troullinos has done is an example. There are a couple of others, and as time permits, I plan to implement them. Before doing that, I want to see how the user reacts to the software as it is now written.

Sincerely,

John F. Dorsey

JFD/db

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ATLANTA, GEORGIA 30332

ELEPHONE: (404) 894-

September 26, 1984

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This is the sixteenth project report on the dynamic equivalents software package, hereafter referred to simply as the project. This report combines the July and August reports. One of the key issues in building reduced order models of power systems has been deciding how far the model reduction can be taken. If the order reduction is taken too far the accuracy of the model degrades to the point where the information obtained from the model is not reliable.

There have never been any true analytical techniques for determining the proper amount of order reduction. The procedure has been to run some simulations with various reduced order models to try to estimate the approximate point at which the inaccuracies begin to creep in.

When this project was initiated, I had an idea of how some current work in system theory might be applied to this problem. As a consequence, I put a graduate student to work on this problem. The result is a viable algorithm for estimating the proper order reduction for dynamic equivalents. In addition the graduate student, George Troullinos, has written the software necessary to compute this order estimate. That basic software was completed in July. What needs to be done now is to integrate that software into the overall package. At present, it does access the data base in exactly the way I would like it to. That problem is fairly easy to rectify. In addition, this software needs to be included in the interactive software that Kirby Holtam is working on. This too, is not a major problem, and work is proceeding on this front.

The success of George's work has impacted one other option, already completed. It may not be necessary for the user to make much use of the option that allows him to compare linear simulation results of reduced order models against the unreduced model in order to determine the accuracy of the reduced order models. I will leave this option in place since it is already done, but I don't expect the user to need it very often.

Sincerely,

John F. Dorsey

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ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

October 30, 1984

Mr. Clayton Griffin
Manager.System Protection and Control
P.O. Box 4545
Atlanta,Georgia 30302

Dear Clayton:

This is the eighteenth project report on the dynamic equivalents software package, hereafter referred to simply as the project. I have finished modifying the network reduction programs so that they interface to the rest of the software. I have also run all the software in batch mode. That is, for a small system I have taken the power flow, or base case, generated the reduced order model, and then used the reduced order model to create the data necessary for a stability run on the PTI system.

In designing this software I have opted to use what is called a partitioned data set. This is a master data set which contains subsets of data, each with an identifying suffix. For instance, if the partitioned data set is called ENGO.SYSPLNG.DYNEQ.PDS, then a member subset of data might be called ENGO.SYSPLNG.DYNEQ.PDS(TMATRIX). I have opted to use partitioned data sets because it simplifies things for the user. That is, the user only has to create one master file, and there is thus a one to one relationship between base cases and these master files. Otherwise the user would have to create about ten individual files or data sets. Thus the idea of a partitioned data set has great appeal.

Unfortunately, partitioned data sets turn out to be somewhat more difficult to use. Having successfully run all the software for a small system, I ran into some problems trying to use a larger system. I am currently trying to work out the partitioned data set problem with Charlie Manahan. Once that problem is resolved, it should only take Kirby Holtam a week or two to overhaul the interactive software. At that point I hope to be able to turn the software over to the users in Birmingham for testing.

Sincerely,

John F. Dorsey

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TELEPHONE: (404) 894-

May 8, 1985

Mr. Clayton Griffin
Manager, System Protection and Control
P. O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This report covers progress on the dynamic equivalents package during the month of April, 1985. During April I completed the conversion of a data formatting program called OUTPUT, which was part of the original EPRI software package. This program converts network data from one format to another. In particular, it converts the EPRI network data to both the so called "common format" and the Philadelphia Electric format. You may recall that when this program was initiated Southern Company Services wanted this package developed on the VM system, that is, the system of Amdahl computers driven by IBM software located in Atlanta. SCS also requested that I provide a network reduction program. I agreed to do this even though I had not initially envisioned doing so. I made it clear right from the start that I would simply integrate the network reduction routines from the EPRI software with the dynamic equivalents software. A problem arises here because SCS does most of its stability analysis on the Prime based PTI system in Birmingham. The data format for the PTI system is different from the EPRI format. Program OUTPUT converts the EPRI data to the so called common format, and yet another program then converts it to the PTI format. The fact that output also converts the network data to Philadelphia Electric format was a nice bonus, because the Philadelphia Electric stability software is a production grade package on the Amdahl or VM system.

One could well ask why the dynamic equivalents software was developed on one system if it is to be run on a different system. I do not know the complete answer to that question. I suspect several things. One that the Prime based system is pretty well burdened with load flow studies. Further, I believe historically at SCS, the stability analysis has been designated to run on the VM

system.

The successful conversion of this data formatting program meant that I had a complete set of network reduction programs that were fully integrated with the dynamic equivalent software. With all the modules in place, I then proceeded to set up a set of small control programs in the IBM "Job Control Language," commonly referred to as "JCL." I created one such control program for each option and suboption of the dynamic equivalents program. These control programs are what a user submits to the system to execute an actual sequence of computational programs. In effect the JCL tells the system which computational algorithms to execute, in what order, what data will be created by each of the computational routines when it executes, and what is supposed to happen to that data, that is, whether it is to be permanently stored or passed on to a subsequent computational routine.

Having set up the JCL for each option and suboption, I then thoroughly tested each option for two sets of data. The first set of data was a twenty-three generator, 150 bus system. This is a small system which executes very quickly and which has a relatively small printed output, making it nearly ideal for documentation purposes. I also tested all the options with a large 254 generator, 2500 bus system. As part of this testing I created the reduced network and the generator groupings for a dynamic equivalent that could be used for a disturbance at Plant Scherer. This was the disturbance picked by Southern Company Services for an initial test of the software. About the third week in April, I notified SCS of the permanent data files that contained the data for this test run.

At this stage I began to work on the documentation for the system, and to clean up the source code. By "clean up," I mean I began to refine some of the input/ouput format statements in the source code so that the printed output for each software module was easier to read, and more informative. This is a fairly routine event that one expects to do once most of the testing is done. I say routine, but two years of working on this project has taught me that nothing is routine on an IBM system. What happened is prototypical of the difficulties I have encountered over the last two years, and so I think it is worth discussing in detail.

I made some very minor changes to a couple of the program modules and recompiled them. The system report on the compilation was normal and said, in effect, that the modules had successfully compiled and had been loaded on the VM system for execution. However, when I tried to execute the modules they would not execute. Bear in mind that these difficulties arose spontaneoulsy on Monday, April 27th. The previous Saturday, I had spent seven or eight hours making similar minor changes and improvements, recompiling modules and successfully executing them. The following Monday these same procedures failed to work. Several "knowledgeable" programmers looked at the system error message and simply shook their heads.

No one had any idea what the problem was. A week later, the problem has still not been solved, and for the two hundreth time in two years, I am dead in the water because of some system problem. I would venture to say that in the last two years, a good ninety per cent of the time I have spent working on this project has been spent trying to overcome problems of the type I have just described.

I have taken the time to recount this incident, because it bears upon two very different understandings of what this project was supposed to accomplish. My understanding was that this was to be a cooperative effort, with some input from Southern Company Services. In particular, SCS was to provide something on the order of six to nine man months of labor, labor I deemed necessary if the software was to ever reach production level.

Southern Company Services view is that I am just another outside contractor. This was not my perspective of the project when undertook it, but as it became clear to me that this was the view of Southern Company Services, I tried to accomodate that point of view. This may have been a mistake, because it meant that I became involved in a day to day struggle to learn enough about the system so that I could accomplish the project goals. This certainly detracted from my ability to make the contribution I had intended to make which was a viable method of generating dynamic equivalents. Fortunately, for most of the contract I had the help of a very able student George Troullinos. The fact that we made significant progress in the understanding of dynamic equivalents is undeniable. George published two journal articles on his work on estimating the order of dynamic equivalents and this year won the outstanding master's thesis award at Georgia Tech.

The fact that I have spent the last two years trying to make sense of the system procedures on the VM system, in effect letting myself be reduced to the status of a programmer, simply reflects my willingness to do whatever is necessary to keep a good working relationship with Georgia Power and Southern Company Services. As I indicated earlier, I think this project is nearly in a form that will prove very beneficial to SCS, if I can overcome some of the problems I have encountered with the system software.

However, this latest fiasco with the VM system has convinced me that the present mode of operation has to cease. It is simply ridiculous for me to waste ninety per cent of my time on this project, dealing with system procedures that should be handled by someone trained and paid to do that kind of work.

With that said, I would like to consider what can be done to bring this project to a successful conclusion. First of all, one of the programmers in Department 471 has to start spending about eight hours a week, doing the necessary housekeeping on the source code to bring it up to production standards. My recommendation is that the analyst be Rhonda Cook. She is the most

competent, the easiest to work with and she is also familiar with the Prime. This will be a big help, if this software ever has to be converted to the Prime. A big if.

Second, the Transmission Planning Group has to decide if they want to use this software, and if so, whether it will be used on the Amdahl system in Atlanta or on the Prime system in Birmingham. Once that decision is made, then it is possible to begin work on the interactive software that interfaces the user to the computational modules. I see no reason to proceed with this stage of the program until a decision is made on where the software is to be used, in the event it is used.

I think that a meeting is in order. I do not care whether the meeting is in Atlanta, or in Birmingham, but I think all the interested parties should be present. That inlcudes a representative of the party paying for the project, Georgia Power, representatives from SCS Transmission Planning, who presumably will use the software, and representatives from Department 471 who are going to have to do some of the work that remains on this project. Roger Webb has expressed a desire to be at that meeting, and suggested that we hold it in Atlanta on either May 23rd or May 24th. I hope this provides enough lead time to set up the meeting.

Sincerely,

John F. Dorsey

Dr. J. F. Dorsey
GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-2945

April 3, 1985

Mr. Clayton Griffin
Manager, System Protection and Control
P.O. Box 4545
Atlanta, Georgia 30302

Dear Clayton:

This is the nineteenth report on the dynamic equivalents project, and covers the period from November of 1985 through March of 1985. The month of November was spent reorganizing several of the basic computational modules to accomodate the order estimation routines that George Troullinos had written. George's work was initially considered just research, but it proved so successful, that I wanted to incorporate it into the mainstream of the project. To do so required modifications to several programs that had already been written, including STEP, TRED and CGROUP. During this period I continued to pursue a data management problem that had first occurred in August. This problem concerned partioned data sets. A partioned data set is a master data set which contains subsets, called "members" which can be specified by the user. This is a very convenient mechanism. In the context of the current project it would allow the user to specify a single partioned data set, which could be associated with a particular case study, and then store all data sets related to this case study as members of this master set. Although all of the major software routines had been successfully tested without using partioned data sets, they would not function using partioned data sets. The problem had been turned over to a number of system experts, but as of November,

1984 this problem had not been reolved. It was finally resolved about four months later. During December I continued my efforts to convert the EPRI programs that perform the network reduction operations, and to integrate them with the routines that produce the groupings for the generators. The basic idea is this. Given an unreduced system, determine which generators form coherent groups. The pass the generator groupings and the unreduced network to the network reduction programs which then reduce the number of buses and lines, so that the actual stability computation can be done faster. My concern here was to make this sequence of events as transparent to the user as possible, and yet still provide the user with as many options and flexibility as possible. During January I continued work on the network reduction programs and had that problem pretty much in hand by the end of the month. At that point in time, I still did not have a resolution of the problem with partioned data sets. In effect, I had detoured around this problem and continued to work on other aspects of the project while awaiting a solution from the system programmers. By February, the software had jelled into five options. The first three options determine actual reduced order models, and give an estimate of the order of the model. The fourth option takes the output from one of the first three options and does the network reduction. The fifth provides a hard copy map of all the generators in the system, by coherent groups. By the end of the month I had tested all five options using two example systems, one a 23 generator, 150 bus system, the other a 254 generator, 2500 bus system. At this point I still had no resolution of the partioned data set problem. In March, I began working on the documentation for the project, and towards the end of the month took a rudimentary form of the documentation with me to Birmingham to confer with Transmission Planning. The major outcome of this meeting was that the reduced

network data produced by option four is incompatible with the PTI stability software on the Prime. The latter half of the meeting was devoted to trying to resolve this data mismatch. In essence a program has to be written which will put the data in a format acceptable to the PTI program. I am currently at work on this last problem. I am hoping that I can modify the existing network reduction programs, so that the data ends up in the proper format. It is difficult for me to estimate how long this will take. It is always difficult to modify someone else's software. I am also continuing work on the documentation for the program.

Sincerely,

John F. Dorsey

JD/ck

SEAS SOFTWARE
VOLUME ONE
USER'S GUIDE

1 Introduction

This documentation describes a set of Fortran 77 programs designed to produce reduced order power system models, often called dynamic equivalents" or just "equivalents," for use in transient stability studies.

The equivalents that are generated by this software are coherency based, in the sense that order reduction is accomplished by replacing groups of generators that accelerate at the same rate by single equivalent generators. However, the coherency expresses underlying structure. That is, the groups are formed by a probabilistic disturbance procedure that detects structure conditions that cause the coherency. For that reason the software has been given the acronym "SEAS," short for Structural Equivalent Analysis Software.

The programs in this software package can be executed directly in batch mode on the Southern Company Services MVS system, or an interactive program called "SEAS" can be invoked which will query the user for the proper information, and then submit the batch job automatically. The documentation provides the user with the information necessary to pursue either avenue. There are five available options described in this documentation. These options allow the user to create three different types of reduced order models, or equivalents, do the necessary network reduction once the generator groupings which constitute the model are determined, and make a map of the model. These five options are described in general terms in the sequel. A more complete explanation of the theory behind these models is provided in Appendices I and II.

Option one creates a global model of the system. That is, given the base case load flow data, a model is determined where the groupings are based on strong connections between generators. The groups can be thought of as areas that oscillate against each other during a very severe, perhaps system wide, disturbance. Such a model is a very useful place to begin, because it provides a global view of system behavior. It also provides one way to identify generator groups that can be used in option two.

Option two creates what will be called a "local" model. A "local" model is a model that can be used to study a disturbance at any of the generators in a particular group. The generators of each group of the model represent machines that are very tightly connected. A disturbance at any one of them will propagate very rapidly to the other machines of the group and then more slowly to the machines outside the group. Thus, the machines of the group to which the disturbed generators belong constitute what is normally thought of as the "study system," while the rest of the power system constitutes the "external" system. The idea is to determine a reduced order model of the external system that can be used to analyze a disturbance at any

SEAS SOFTWARE
VOLUME TWO
SAMPLE OUTPUT

10 Sample Test Runs Of All Five Options

This section is comprised of sample test runs of all five of the SEAS options. Sample runs for the first three options are made for both case where the balanced system is used to estimate the order reduction, and for the case where the order estimation is based upon the controllability grammian. The sample runs using the balancng option include the user data entry, the actual JCL statements used to execute the option, and the printed and plotted outputs. Since the output using the controllability grammian for order estimation is a subset of the output using balancing, only the user data entry and the actual JCL statements are included for those sample runs where the controllability grammian is used for order estimation.

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APPENDICES I AND II

I. INTRODUCTION

The production of reduced order dynamic models (dynamic equivalents) of power systems has been a topic of continuing interest over the last decade. Three of the principal techniques proposed for determining these reduced order models are coherency analysis, modal analysis, and singular perturbation theory.

Coherency analysis (Podmore and Germond, 1977, 1978a, 1978b) consists of simulating on a computer the response of the unreduced power system to a specific disturbance and observing which generators accelerate at the same rate, thereby maintaining the same relative angle difference and remaining "coherent." Coherent generators are then combined (aggregated) into a single generator to reduce the order of the model.

The modal analysis approach (Undrill and Turner, 1971) divides a linearized model of the power system into an internal system and an external system. The disturbance is assumed to occur within the internal system; the order reduction occurs in the external system. Modes identified with the external system are discarded if they are not excited, decay quickly to zero, or are either uncontrollable or unobservable.

The singular perturbation method (Chow, Allemong, Kokotovic, 1978) also divides a linearized state model of the power system into two parts, but the division is on the basis of whether the modes are "fast" (high frequency) or "slow" (low frequency). The slow modes represent oscillations between "principal" groups (Avramovic & Colleagues, 1980) of generators. The fast modes represent oscillations between individual generators of the principal groups. The state model then takes the form of Equation (1). The order reduction is accomplished by assuming that the fast modes,

Final Report

Dynamic Equivalents Project

The project to develop the necessary software to compute reduced order models of large scale power systems is complete. This software consists of:

1. Computational modules that compute generator groupings based on modal-coherency and then reduce the network based on the groupings.
2. An interactive program that serves as an intermediary between the user and the computational modules.

The documentation for this project, included as part of the final report, consists of three volumes. Volume I is a user's guide. It is aimed both at the user who has no interest in programming, and at the more sophisticated user who has programming skills and may at some point wish to manipulate either the source code of the computational modules, or the sequence in which the modules are executed.

Volume II is a list of sample outputs for all five options of the software. The test system used is a twenty-three generator, 150 bus model of the southwestern portion of the Southern Company. The test system is large enough to demonstrate most of the features of the software, and small enough that the printed output can be contained in one medium size volume.

Volume III consists of two monographs that provide the analytical basis for software. The first monograph describes the method for determining the generator groupings, based on the modal-coherency approach. The second monograph describes the method used to estimate the amount of feasible order reduction.

As described in Volume I, the software provides the user with three different procedures for determining a reduced order equivalent. Option I, produces models obtained by applying probabilistic disturbances to all generators. Option II produces models based upon the disturbance of a selected group of generators. Within Option II there are three suboptions each providing a somewhat different approach to the selection of the generators to be disturbed. This provides the user wide latitude in determining which generators to disturb. Option III produces equivalents based upon the application of up to eight simultaneous faults to the system.

The decision to provide the user with a variety of techniques for generating reduced order models, reflects the state of the art in dynamic equivalents. There is currently no one technique or one expert who can say with complete confidence exactly how dynamic equivalents should be determined. The modal-coherency approach has shown very good promise, but precisely how it should be applied in practical cases is still not perfectly clear. The first three options of this software apply the modal-coherency approach in what seem to be the most sensible ways. As

testing proceeds, one of the methods of selecting the generators to be disturbed will probably prove superior.

Option IV allows the user to reduce the power system network, subject to the generator groupings determined by one of the first three options. The network reduction programs are adaptations of the EPRI programs GENRED, LODRED and DYNAGG from the EPRI dynamic equivalents software package. In talking with various utilities, it is clear that a good deal of work needs to be done in the area of network reduction, particularly in connection with dynamic equivalents. The EPRI network reduction programs are widely used, and were selected for that reason. How effective these programs are when used in conjuction with the generator grouping programs, remains to be seen.

Option V provides the user with the ability to draw a map of his system and to identify the generators in the system by physical location and coherent group. This is an option that has both supporters and detractors. It's value is greatest when the user is not totally familiar with the system under study.

The testing of this software has been initiated. However, to thoroughly test this software will certainly be a lengthy affair. There are really two issues involved in the testing. The first is to determine if the generator groupings are valid. If, in fact, the generator groupings are viable, the second issue is to see how the network reduction impacts the validity of the equivalent.

Since testing of this type is tedious, time consuming and costly, it can probably best be tackled in cooperation with other utilities. Several utitlities have expressed an interest in testing this software, including Ontario Hydro, Pacific Gas and Electric, and Consumers Power.

The proposed division of labor is as follows. Since Ontario Hydro is primarily interested in global models, they will test Option I. Option II is currently being tested by Southern Services. Consumers Power usually works quite closely with Michigan State University. They would test Option III. Pacific Gas and Electric would be free to test any option, but would be encouraged to test Options I and II.

The decision to release the software to these utilities for testing purposes is the perogative of Georgia Power and Southern Company Services. The decision to do so would greatly facilitate the testing process.